TEST METHODS FOR SODALIME
CARBON DIOXIDE ABSORBENTS

AUGUST 2002

CDR E. T. LONG

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NAVY EXPERIMENTAL DIVING UNIT

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NAVY EXPERIMENTAL DIVING UNIT
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AUGUST 2002

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Insert latest changed pages; dispose of superseded pages in accordance with applicable regulations.

On a changed page, a vertical line in the margin indicates that portion of the text affected by the latest change. Changes to figures are indicated by miniature pointing hands.

Date of issue for original pages is August 2002.

Total number of pages in this publication is 27, consisting of the following:

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** A zero in this column indicates an original page.*

RECORD OF CHANGES

Except as provided herein, changes will be made only on the authority of the NEDU Commanding Officer. A dark vertical line in the margin indicates the extent of the change.

CHANGE NO.	AUTHORITY	INSERTION	SECTION	INITIAL

SAFETY SUMMARY

The following are general safety precautions that are not related to any specific procedures; therefore, they do not appear elsewhere in this document. These are recommended precautions that personnel must understand and use during various phases of testing and evaluation.

STANDARD SAFETY PRECAUTIONS:

Safety precautions for unmanned testing are normal precautions associated with testing at pressures of 5000 psig or less. To minimize safety risks, operating personnel shall adhere to the test procedures as presented in this manual when they conduct UBA testing. Failure to perform the procedures as prescribed may cause injury to personnel or damage to equipment.

Operating personnel must observe all applicable safety regulations in compliance with the Navy Occupational Safety and Health (NAVOSH) Program Manual, OPNAVINST 5100.23E with change 1.

Carbon dioxide (CO_2) absorbents currently used in manned hyperbaric chambers and underwater breathing apparatus (UBA) authorized for use in the U.S. Navy primarily consist of calcium hydroxide ($Ca(OH)_2$) [hydrated lime] and sodium hydroxide (NaOH) [sodium hydrate], which can cause irritation or burns to the eyes and/or skin.

Before conducting the procedures outlined in this technical manual, the operator should review the Material Safety Data Sheet (MSDS) for the product under investigation.

The following is extracted from the MSDS for Sofnolime, manufactured by Molecular Products Ltd., United Kingdom:

FIRST AID	Inhalation	Remove from exposure. Obtain medical attention.
	Skin	Drench with clean water. Obtain medical attention.
	Eyes	Irrigate with clean water. Obtain medical attention.
	Ingestion	Wash out mouth. Obtain medical attention.
ACCIDENTAL	Personal	Avoid inhaling dust. Avoid skin and eye contact.
RELEASE	Environment	No hazard.
	Recovery	Contain material. Sweep or vacuum up.
PERSONAL	Respiratory	Dust mask recommended.
PROTECTION	Skin	General-purpose rubber gloves.
	Eyes	Glasses to protect against dust.
	Hygiene	Wash after skin contact.

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INTRODUCTION

This manual describes Navy Experimental Diving Unit (NEDU) procedures for determining carbon dioxide (CO_2) absorbent particle size, friability, moisture content, and performance.

The instrumentation and test methods described herein should allow any test facility to reproduce the tests conducted by NEDU. Any test instruments comparable to those specified in the test setup may be used, provided that the response characteristics and accuracy of the instruments are equal to or exceed those used by NEDU and that their calibration is traceable to National Institute of Science and Technology (N.I.S.T.) standards.

Previously, these studies were conducted according to procedures listed in enclosure (1) of reference (1). Progressive modifications to the procedure have followed NATO Standards development and reference (2), Standard NATO Agreement 1411 (UD), is the source document for this manual.

This manual is meant to be dynamic, and the methods described are valid as of June 2002. It is not meant to be all-inclusive, however: experience and individual instruction are still required to conduct accurate tests. As instrumentation technology advances and new test methods are developed, this manual will be updated to include changes that improve the procedures. However, only changes authorized by the Commanding Officer, NEDU, are to be incorporated into these procedures and/or this manual.

PART I

SIEVE MESH and SCHLEGEL FRIABILITY ANALYSIS

1.1 EQUIPMENT REQUIRED:

A. Ro-Tap Shaker, W. S. Tyler, Inc., Gastonia, NC; or equivalent

B. Clean, dry U.S. 3.5 mesh screen pan

C. Clean, dry U.S. 5 mesh screen pan

D. Clean, dry U.S. 8 mesh screen pan

E. Clean, dry U.S. 10 mesh screen pan

F. Clean, dry U.S. 14 mesh screen pan

G. Clean, dry U.S. 30 mesh screen pan

H. Clean, dry retaining pan for shaker

I. Ohaus Explorer balance, Model EOD110 (3,000-gram capacity, resolution to 0.1 g), Ohaus Corp., Pine Brook, NJ; or equivalent

U.S. Sieve (ASTM E-11)	Tyler Sieve	British (BS 410)	Aperture (mm) ISO std.
3.5	3.5	3	5.60
4	4	4	4.75
5	5	-	4.00
6	6	5	3.35
7	7	6	2.80
8	8	7	2.36
10	-	8	2.00
12	10	10	1.70
14	12	12	1.40
30	28	25	0.60
40	35	36	.425

Table 1. Sieve Mesh Size Conversions

1.2 PROCEDURE:

A. Zero the balance. Ensure that the pans are clean and free from entrapped granules. Weigh each mesh screen and base pan. Record their empty weights on the CO_2 Absorbent Sieve Mesh and Friability Analysis Data Sheet (Annex A).

B. From a bucket/pail of material to be tested, divide the samples into five plastic bags. Samples will be divided in the following manner:

(1) Divide the total weight of the container by 6.
(2) Place a plastic sample bag on the balance, and pour one-sixth of the container into this bag.
(3) Repeat step (2) 4 more times.
(4) Discard the final one-sixth or the last 5 cm (whichever is greater) that remains in the container.
(5) Label the bags with numbers from 1 through 5.

NOTE

1. Do not use the last 5 cm (2 in.) of granules from the container.

2. While dividing the absorbent for the sample bags, be aware of any objectionable odors such as those of ammonia, urine, rotten eggs, or others that smell suspicious. If such odors are present, STOP THE TEST and seek advice from the Task Leader, Medical Officer, or Scientific Director.

3. While dividing absorbent among the sample bags, be aware of the color of the granules. "Indicating" absorbent (usually identified by a purple color) is NOT AUTHORIZED for use. If the absorbent appears to have an indicator included, STOP THE TEST and seek advice from the Task Leader, Medical Officer, or Scientific Director. Part IV of this manual gives instructions for using an acid test to determine whether or not an absorbent has indicating dye.

C. Zero the balance. Measure 100 (±0.1) grams of the sample from bag number 1, and distribute this amount evenly in the top sieve (U.S. 3.5 mesh screen pan). Seal the mixed bag, and set it aside for further testing.

D. Assemble the Ro-Tap mesh screens [see 1.1(A) through 1.1(H)], and nest these screens in order of their mesh sizes, with the coarsest at the top.

E. Place a lid on the shaker, and run the shaker for 5 minutes.

F. Remove the nest of mesh screen pans from the shaker and weigh the amount of material retained on each sieve as well as that of the dust on the retaining pan at the base of the nest. Record these posttest weights on the SIEVE MESH ANALYSIS DATA section of the CO_2 ABSORBENT SIEVE MESH and FRIABILITY ANALYSIS DATA SHEET (Annex A). Subtract the weight of the empty pan (its pretest weight) from its posttest weight. The weight of the absorbent retained on each mesh screen equals the percent of the sample that corresponds to that mesh size. For example, 35.4 grams retained on a screen equals 35.4 percent of the sample. Record these results carefully.

NOTE

Any granules lodged in the meshes of a sieve shall be included in the calculations with the material retained on the sieve.

G. After performing steps C, D, E, and F for the sample from the bag number 1, clean the pans, take a new sample from one of the bags numbered 2 through 4, and repeat this sequence of steps. After each repetition of this sequence with a sample from the bags numbered 1 through 4, discard the tested sample in an appropriate container for disposal.

H. With a sample from bag number 5, repeat steps C through F in sequence and, after completing step F with this last sample, **DO NOT EMPTY THE PANS**.

I. Reassemble the Ro-Tap mesh screen pans. Run the shaker for an additional 55 minutes.

J. Repeat step F. Record the results in the FRIABILITY ANALYSIS DATA section of the data sheet (Annex A). Discard this last sample in an appropriate container for disposal. Wash and dry the pans before storing them.

K. Provide the data sheet to the Project Officer or Principal Investigator.

L. Analysis of this data may be performed with *MeshFit* software and program. Information concerning this program may be found in reference (4).

PART II

ABSORBENT MOISTURE CONTENT ANALYSIS

2.1 EQUIPMENT REQUIRED:

A. Digital moisture balance, model AD 4713, A & D Company, Ltd., Tokyo, Japan; or equivalent

B. Sample pan

C. Sample pan foil inserts

D. Instruction manual for digital moisture balance

2.2 PROCEDURE (FIRST SAMPLE):

A. Verify that the instrument is within calibration. Enter the calibration date, calibration due date, and other required information on the CO_2 ABSORBENT MOISTURE CONTENT ANALYSIS DATA SHEET (Annex B).

B. Verify that the instrument is level — as indicated by the "bubble level" at the rear.

C. Turn the power switch ON, and wait for the instrument to initialize.

D. Verify that the drying temperature is set at **250 °C** (482 °F) [see reference 1].

E. Verify that the drying time is set at **15 minutes** (see reference 1).

F. Place the clean, dry sample pan and foil insert on the balance. This sample pan and the foil insert should be at room temperature.

G. Press the "**TARE**" key to zero the balance. The display will indicate "0.000 g."

H. Remove a 15 (±1)-gram random sample from bag number 1 (of the previously numbered bags used in the sieve mesh analysis). Distribute the sample evenly on the foil insert.

I. Firmly close the lamp cover.

J. Record the "Start Weight" (to 0.001 g) on the data sheet.

K. Press the "START/STOP" key. The lamp will light, and the test will begin.

L. When the "BUZZER" sounds, press the "START/STOP" key. Record the PERCENT MOISTURE (to 0.1%) on the data sheet.

M. Press the "RESET" key, and record the "END (dry) WEIGHT" (to 0.001 g) on the data sheet.

N. Open the lamp cover. Using tongs or tweezers, carefully remove the sample pan and foil insert from the balance. Discard the sample in an appropriate container for disposal.

CAUTION: The sample pan and foil insert will be VERY HOT.

2.3 PROCEDURE (SUBSEQUENT SAMPLES): Use a new sample pan and foil insert. (An alternative is to allow the previously used analyzer, sample pan, and foil insert to cool, to prevent pretest moisture from evaporating from the sample.)

NOTE: The acceptable moisture content derived for optimum material performance ranges from 14% to 19%.

A. Repeat steps 2.2(F) through 2.2(N) for the remaining samples from bags numbered 2 through 5.

B. At the completion of testing, turn the power switch OFF.

PART III

ABSORBENT ACTIVITY ANALYSIS

3.1 EQUIPMENT REQUIRED:

A. Three clean, dry glass cylinders with 30-millimeter inside diameters and 105-milliliter volumes, P/N CS2580, Radley's Ltd., Essex, U.K.

B. Three clean, dry 1.5-millimeter stainless steel mesh retaining screens with 30-millimeter outside diameters

C. Ohaus Explorer balance, model EOD110 (3,000-gram capacity, resolution to 0.1 g), Ohaus Corp., Pine Brook, NJ; or equivalent

D. Rosemount NGA 2000 nondispersive Infrared CO_2 Analyzer with 0–5000 parts-per-million (ppm) range, Rosemount Analytical, La Habra, CA; or equivalent

E. Calcium chloride desiccant (4–20 mesh), product number C614-3, Fisher Chemical, Pittsburgh, PA; or equivalent

F. Certified challenge gas: 5.00% CO_2 (±0.05) in nitrogen, with certificate of analysis

G. Certified analyzer calibration gas: 185–199 ppm CO_2 in nitrogen, with certificate of analysis

H. Certified analyzer calibration gas: 4850–4950 ppm CO_2 in nitrogen, with certificate of analysis

I. Certified analyzer zero gas: 100% nitrogen or "zero CO_2 air," verified by the CO_2 analyzer [item 3.1(D)]

J. Cork or rubber pad (for tamping samples into cylinders), 6" x 6" x 1/4"

K. Data acquisition system computer

3.2 PROCEDURE:

A. Start up the computer data acquisition system (DAS).

1. Verify that the monitor, central processing unit (CPU), and printer are **ON**.

2. Place the mouse pointer on the monitor's "**NATO**" icon and double-click it.

3. Single-click on "**ENABLE**" at the top of the monitor screen. Ensure that "**LOGS OFF**" is selected.

4. Single-click on "**WINDOWS**" at the top of the monitor screen. Single-click on "**SHOW WORKSHEET**."

5. Double-click on "**DISK ICON**" (should be on the right of the worksheet).

    a. Update the notes field and select "**SAVE AS**."

    b. Enter a file name (consisting of manufacturer, batch number, and run number. Example: **sof#1111111run1**). Single-click "**SAVE**."

    c. Select "**OK**."

    d. Check the desk icon to ensure that the name you selected is indicated below it.

6. Single-click on "**WINDOWS**" at the top of the monitor screen. Single-click on "**HIDE WORKSHEET**."

7. Reset your graphs.

8. Reset switch number 2 to the "**SET**" position and switch number 1 to the "**OFF**" position.

B. Calibrate the CO_2 analyzer.

1. Ensure that the analyzer has been powered (plugged in) for a minimum of two hours.

2. Verify that the analyzer range is set to 5000 ppm. Follow the NGA 2000 analyzer manual for zero gas calibration procedures.

3. Connect the analyzer inlet to the zero gas. Adjust the flow to 250—300 mL/min. Allow the display to stabilize.

4. Follow procedures in the NGA 2000 analyzer manual to make adjustments, if required.

5. Connect the analyzer inlet to the span gas (4850–4950 ppm CO_2). Adjust the flow to 250–300 mL/min, and allow the display to stabilize.

6. Follow procedures in the NGA 2000 analyzer manual to accomplish span gas calibration. Press the **SPAN**, and then the **ENTER** keys. The analyzer will display "[CALCULATING SPAN]" and will return to the RUN mode after a delay of about 15 to 20 seconds.

7. Check the ZERO setting: repeat step 3. If the error exceeds 2 ppm, repeat step 4.

8. Check the SPAN setting: repeat step 5. If the error exceeds 2 ppm, repeat step 6.

9. Repeat steps 7 and 8, as necessary, for stable ZERO and SPAN settings.

NOTE: If the analyzer will not stabilize at ZERO or SPAN, refer to the NGA 2000 analyzer manual or seek assistance.

10. Log the ZERO, 200-ppm, and SPAN data to the computer DAS.

C. Pack the desiccant cylinder.

1. Clean the cylinder with warm water and a nylon bottlebrush. Dry the cylinder thoroughly.

2. Place one retaining screen at the bottom of the glass cylinder, where it can rest on the internal retaining indention.

3. Carefully pour approximately 10 cm (4 in) of nonabsorbent filler material, such as glass beads or marbles, into the cylinder.

4. Place a second retaining screen on top of the filler material. Be careful to keep this screen seated squarely in the cylinder.

5. Carefully pour approximately 5 cm (2 in) of calcium chloride desiccant into the cylinder.

6. Using the retaining bracket, attach the filled cylinder to the test board.

7. Firmly press the top and bottom stoppers into the cylinder. Twist the stoppers, as you press them into the cylinder, to ensure a gas-tight fit.

D. Pack the absorbent cylinder.

1. Using a suitable container, remove sufficient quantities of mixed absorbent material from bag number 1 to fill the sample tube.

2. Place one retaining screen at the bottom of the clean glass cylinder, where it can rest on the internal retaining indention.

3. Place the cylinder on the digital scale. Press the "TARE" key. The display will indicate "0.000 g." Remove the cylinder from the scale.

4. Being careful to keep the screen seated squarely on the internal retaining indention, pour approximately 2.5–3.0 cm (1.0—1.2 in) of absorbent into the cylinder.

NOTE: The SNOW STORM FILLER method may also be used to fill the cylinder.

5. Being careful not to dislodge the screen, pack the absorbent by gently tapping the cylinder on the cork or rubber pad.

6. Continue to fill the cylinder to the **105-mL** mark by adding a small quantity of absorbent and tapping the cylinder each time on the cork or rubber pad.

NOTE: The amount of absorbent added each time should be small enough that the absorbent particles become closely packed together after the cylinder is tapped on the pad about 10 to 20 times. Particles are sufficiently packed if they do not move when the cylinder is tilted slightly and rotated.

7. Place the filled cylinder on the scale. Record the Start Weight on the CO_2 ABSORBENT ACTIVITY ANALYSIS DATA SHEET (Annex C).

NOTE: Do not "Zero" or "Tare" the scale. The scale will be required to determine a posttest cylinder weight.

8. Using the retaining bracket, attach the filled cylinder to the test board (Figure 1).

9. Firmly press the top and bottom stoppers into the cylinder. Twist the stoppers, as you press them into the cylinder, to ensure a gas-tight fit.

E. Calibrate the absorbent Test Bench differential pressure transducer (EDF-SWP-12).

1. Turn on the absorbent Test Bench computer and monitor.

2. Depress "**control alt delete.**"

3. Log in, using "**t&e**" as user name and "**gateway**" as password.

4. On the absorbent Test Bench computer, double click on the "**calibration**" icon.

5. Select the transducer to be calibrated and, on the corresponding computer, move the cursor to "**channel.**" Depress the left mouse button and hold it down; scroll to "**differential pressure**" and then release it.

6. Disconnect the positive and negative sides of the transducer.

7. Install a one-eighth-inch flexible tube from the positive side of the differential pressure transducer (Validyne Model P55D, 3-V-4-24-S-4-A) to the pressure side of a manometer (e.g., Meriam Instrument).

8. Apply a maximum of 8.9 inches (22.5 cm) of water pressure to the transducer. Verify the reading on the computer.

9. Using the manometer, vary the water pressures between 0 and 8.9 inches and verify the readings against the computer. Once these readings are acceptable, the calibration is complete: accept the values.

10. Reset the manometer to zero, open and bleed it, and then hit "**OK**" on the absorbent Test Bench computer.

11. Disconnect the manometer and restore the Test Bench to its operating configuration.

F. Conduct the activity analysis (first sample).

1. Testing will be conducted at 20±1 °C (68±1.8 °F). Record the room temperature on the CO_2 ABSORBENT ACTIVITY ANALYSIS DATA SHEET (Annex C).

2. Testing will be conducted at 1 ATA.

3. Disconnect the analyzer inlet.

4. Connect the quick-disconnect (QD) connector to flow zero gas. Adjust the TOTAL system flow to 3000 mL/min (±0.1 L/min), as noted on the digital gas mass flowmeter.

5. Connect the analyzer inlet. Adjust the analyzer flow to 250–300 mL/min.

NOTE: The TOTAL system flow will decrease in proportion to the analyzer flow. Note this value (which should be 2700–2750 mL/min) for use in step 7 below.

6. Connect the QD connector to flow the challenge gas (5.00% CO_2), and start keeping logs. Push the start time on the computer DAS while simultaneously initiating the flow of the challenge gas. THE TEST HAS STARTED.

7. Adjust the analyzer flow and the TOTAL system flow, if necessary, to the values noted in step 5 above.

8. Allow the test to run until the sample absorbent effluent (as indicated on the analyzer and the computer screen) reaches 5000 ppm (0.5%) CO_2. Record the times at which the CO_2 levels reach 200 (0.02%) and 5000 ppm (0.5%) CO_2. Stop the test at 5000 ppm. Print the screen.

9. THE TEST IS COMPLETED. Stop the logs on the computer DAS. Record the test time on the data sheet. Print the screen.

10. Disconnect the QD connector to stop the challenge gas flow.

11. Perform the posttest CO_2 analyzer CALIBRATION CHECK:

    a. Connect the analyzer inlet to the zero gas. Adjust the analyzer flow to 250–300 mL/min. When the reading is stable, log the analyzer output value in the DAS file.

    b. Connect the analyzer inlet to 185–199 ppm span gas. Adjust the analyzer flow to 250–300 mL/min. When the reading is stable, log analyzer output value in the DAS file.

    c. Connect the analyzer inlet to the span gas (4850–4950 ppm). Adjust the analyzer flow to 250–300 mL/min. When the reading is stable, log the analyzer output value in the DAS file.

    d. Disconnect the analyzer inlet.

    e. Print a hard copy of the computer screen, and file this copy with the data sheet(s).

        1. Stop the logs.

2. Print the "Go to file" screen.

3. Retrieve the hard copy from the printer.

12. Remove the sample cylinder filled with expended absorbent from the test board. Place it on the scale. Record the posttest weight of the sample on the data sheet. Discard the expended sample in an appropriate container for disposal.

13. Install an empty sample cylinder on the test board. Connect the QD connector to flow zero gas. Adjust the TOTAL system flow to 750–1000 mL/min. Using CO_2 free air, purge the system's CO_2 content to LESS THAN 10 ppm, in preparation for the next test. **NOTE:** The purge should take approximately thirty minutes.

G. Conduct the activity analysis.

1. Connect the analyzer inlet. Adjust the analyzer flow to 250–300 mL/min.

2. Verify that the system CO_2 content is LESS THAN 10 ppm. If it is NOT, continue purging it with CO_2 free air.

3. If system CO_2 content is less than 10 ppm, disconnect the QD connector to stop the flow. Disconnect the analyzer inlet.

4. Enter a new file name in the computer DAS.

5. Inspect the desiccant cylinder for channeling or cementing of the desiccant. Replace the desiccant, if necessary, per Procedure C: pack the dessicant cylinder.

6. Repeat Procedure D: pack the absorbent cylinder.

7. Perform the analyzer calibration check per Procedure B, steps 7 through 10.

8. Continue conducting the performance analysis for samples 2 through 5 per Procedure E, steps 4 through 13.

PART IV

ACID TEST FOR INDICATOR DYE

NEDU occasionally needs to determine whether a sodalime sample contains indicating dye. If the sample containing dye has been exposed to exhaled CO_2, the normally white absorbent granules turn blue or purple, indicating that dye must be present. To test unused absorbent, the following procedure is effective.

CAUTION: HYDROCHLORIC ACID (HCl) IS HIGHLY CORROSIVE. USE ACID-PROOF GLOVES AND EYE PROTECTION WHEN WORKING WITH ACIDS.

4.1 Equipment Required

A. 7-mL disposable transfer pipette (Daigger GX20410A)
B. 3-oz plastic cup
C. Nalgene (high-density polyethylene) bottle with screw-on cap: available from PGC
D. 31.45% HCl acid (commercial muriatic acid for pods and masonry cleaning), stored in a 125=Ml Nalgene bottle: available at pool and hardware stores.

4.2 Procedure

A. Place a small amount of dry absorbent into the 3-oz plastic cup. Partially fill the transfer pipette by squeezing the built-in bulb, inserting the tip of the pipette into the bottle containing hydrochloric acid, and releasing the bulb. Move the pipette to the plastic cup and release several drops onto the absorbent.

B. If indicator dye is present, the granules contacted by the acid should rapidly turn blue or purple.

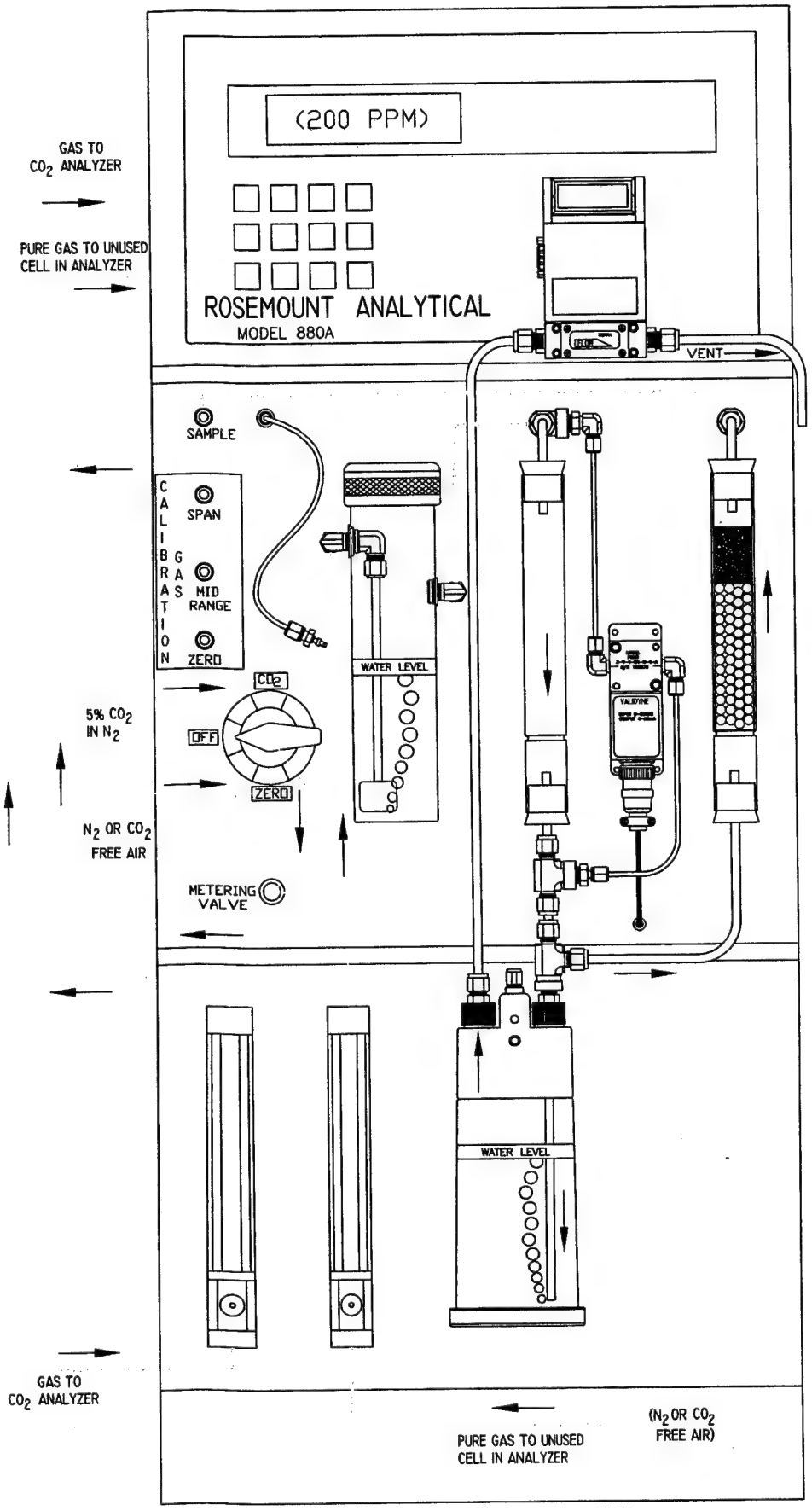
C. Cleanup:

1. Discard the HCl remaining in the pipette into a sink, and dilute this discarded acid with cool water.

Rinse the pipette with water before discarding it.

3. Fill the 3-oz cup with water to dilute the acid. The alkali in the absorbent granules neutralizes most of the acid; water dilution is just an added precaution.

4. Dispose of the remaining absorbent by any approved procedure..



Test Bench for Performance of CO_2 absorbent.

Annex A

CO_2 ABSORBENT SIEVE MESH and FRIABILITY ANALYSIS DATA SHEET

Test Date: _____ **Sample size:** 100 grams **Run Time:** 5 minutes

Absorbent: _____ **Lot No:** _____

Mesh size: _____ **Expiration Date:** _____

NEDU Test Plan No.: _____ **Flow rate (mL/min):** _____

SIEVE MESH ANALYSIS DATA

Run No.		U. S. 3.5		U. S. 5		U. S. 8		U. S. 10		U. S. 14		U. S. 30		PAN	
		WT	Δ	WT	Δ	WT	Δ	WT	Δ	WT	Δ	WT	Δ	WT	Δ
1	PRE														
	POST														
2	PRE														
	POST														
3	PRE														
	POST														
4	PRE														
	POST														
5	PRE														
	POST														
Mean															

FRIABILITY ANALYSIS DATA

(Run 5 Sieve Mesh Analysis continued an additional 55 minutes)

	U. S. 3.5	U. S. 5	U. S. 8	U. S. 10	U. S. 14	U. S. 30	PAN
POST WEIGHTS							

The absorbent mesh size for this lot meets NATO specifications **Yes** **No**

The absorbent friability for this lot meets NATO specifications **Yes** **No**

Operator: _____

Comments: _____

_____

Annex B

CO_2 ABSORBENT MOISTURE CONTENT ANALYSIS DATA SHEET

Test Date: _____

Absorbent: _____ **Lot No:** _____

Mesh size: _____ **Expiration Date:** _____

NEDU Test Plan No.: _____ **Flow rate (mL/min):** _____

Temperature: 250 °C **Run Time:** 15 minutes

Instrument Calibration Date: _____

RUN No.	START WEIGHT (grams)	END WEIGHT (grams)	PERCENT MOISTURE
1			
2			
3			
4			
5			
		MEAN	

The absorbent moisture content for this lot meets NATO specifications **Yes** **No**

Operator: _____

Comments: _____

_____

Annex C

CO_2 ABSORBENT ACTIVITY ANALYSIS DATA SHEET

Test Date: _____

Absorbent: _____ **Lot No:** _____

Mesh size: _____ **Expiration Date:** _____

NEDU Test Plan No.: _____ **Flow rate (mL/min):** _____

Room Temperature: _____

RUN No.	START WEIGHT (grams)	END WEIGHT (grams)	Δ WEIGHT (grams)	TOTAL ACTIVITY (minutes, rounded up)
1				
2				
3				
4				
5				
			MEAN	

The absorbent activity for this lot meets NATO specifications. **Yes** **No**

Operator: _____

Comments: _____

_____

REFERENCES

1. Navy Experimental Diving Unit letter, *Revised NATO Carbon Dioxide Absorbent Evaluation*, 3963/TA92-039 Ser 025/304 of 4 June 1993.

2. MAS (naval) 0958-UD/1411 of 4 Sep 2000 (ED.1) STANAG 1411 UD, Standard to Quantify the Characteristics of Carbon Dioxide (CO2) Absorbent Material for Diving Applications.

3. J. R. Clarke, The Analysis of Sodalime Granule Size Distributions, Navy Experimental Diving Unit, August 2002. NEDU TR 02-08.

GLOSSARY

ATA	atmospheres absolute
°C	degrees Celsius
cm	centimeters
cmH_2O	centimeters of water pressure
CO_2	carbon dioxide
EDF	Experimental Diving Facility (NEDU unmanned test facility)
°F	degrees Fahrenheit
fsw	feet sea water — a unit of pressure (assumes ρ = 1.02479)
in	inches
J/L	joules per liter (unit breathing effort, equivalent to 1 kPa)
kg·m/L	(old form for breathing effort; aka work of breathing) kilogram meters of respired volume
kPa	kilopascal (unit of pressure or breathing effort = 1000 Pa)
L	liters
L/min	liters per minute
$L \cdot min^{-1}$	liters per minute (scientific format)
m	meter
mm	millimeter
min	minutes
msw	meters sea water - a unit of pressure (assumes ρ = 1.01972)
NEDU	Navy Experimental Diving Unit
N.I.S.T.	National Institute of Science and Technology (formerly NBS)
P	ambient pressure
Pa	pascal (unit of pressure = 1 newton/meter^2)
psi	pounds per square inch
psig	pounds per square inch gage
ΔP	pressure differential
s	seconds
UBA	underwater breathing apparatus
USN	United States Navy
ρ	density

Conversions

To Convert From	To	Multiply By
kg·m/L	joules per liter (J/L)	9.807
psi	kilopascals (kPa)	6.895
msw (ρ = 1.01972)	fsw (ρ = 1.02479)	3.2646
fsw	kilopascals (kPa)	3.063
bar	psi	14.504
bar	kPa	100
cmH_2O	kPa	0.0981
J/L	kPa	1.000